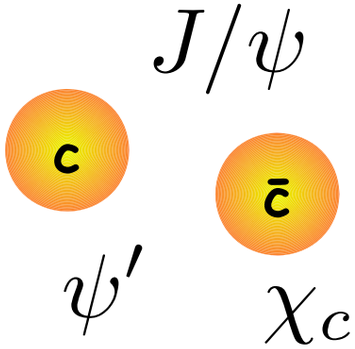
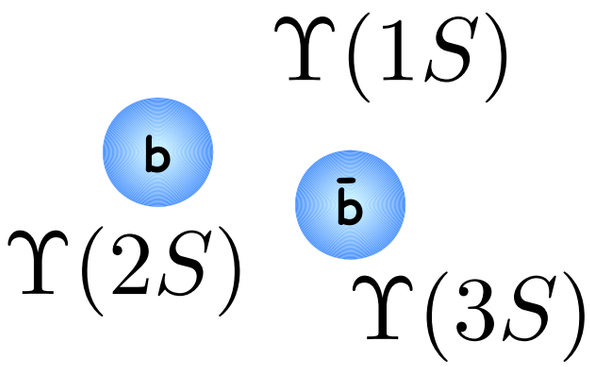
Heavy quarkonia production measured by PHENIX detector at RHIC





Cesar Luiz da Silva
Iowa State University
for the PHENIX Collaboration

PHENIX

Iowa State Cyclones

Some Quarkonia Properties

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	Mass	radius
π	0.14 GeV	0.06fm
p	0.94 GeV	0.87fm
ψ'	3.68 GeV	0.90fm
χ_c	3.53 GeV	0.72fm
J/ψ	3.1 GeV	0.50fm
ϒ	9.5 GeV	0.28fm

- weak coupling with light mesons
- relative small size, strong biding
- sensitive to the environment before hadronization stage in A+A collisions
- All these features make quarkonia an excellent QCD probe

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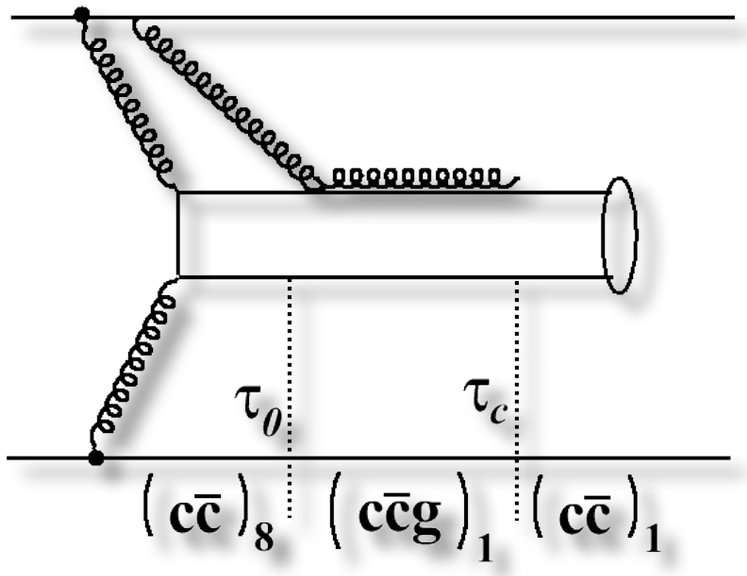

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  - sensitive to gluon distribution in proton and its modification when inside a nucleus

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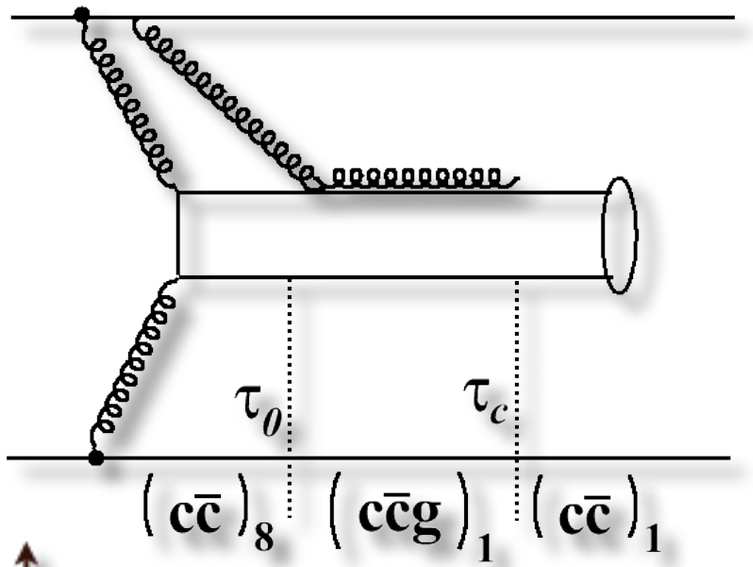

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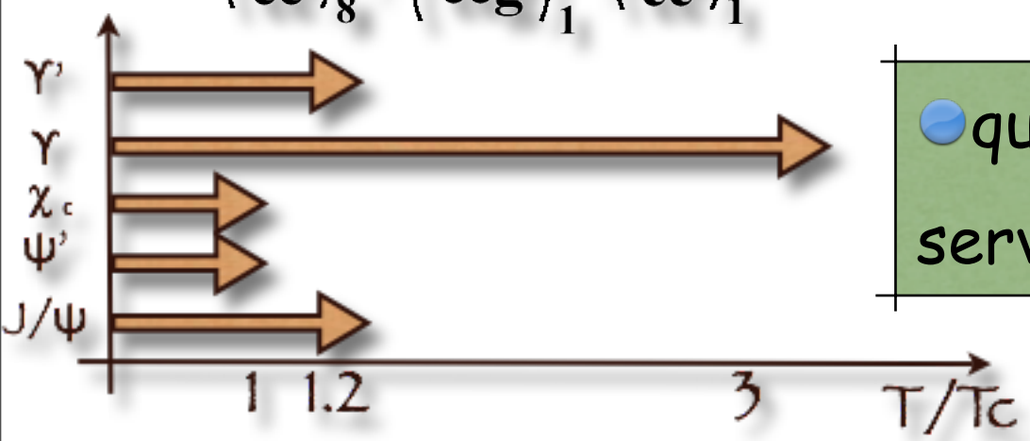
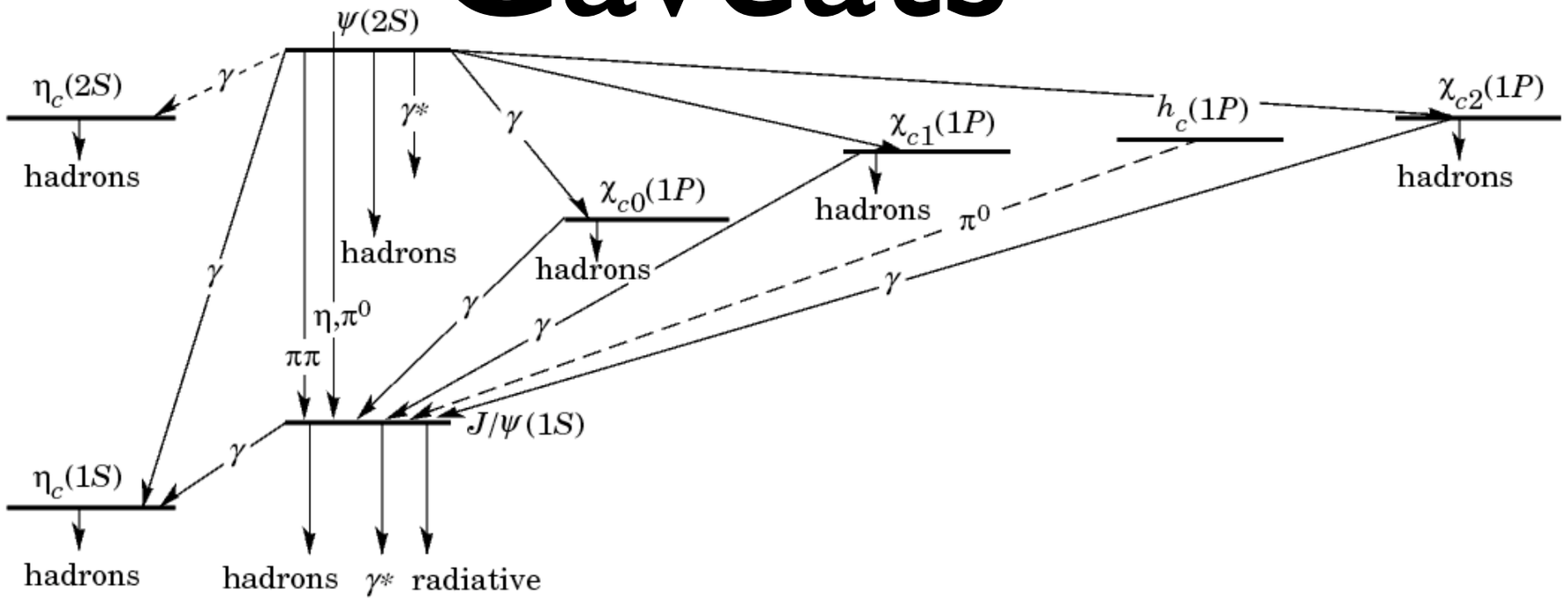


- quarkonium dissociation by color screening could serves as a QGP thermometer

Caveats



- several feed-down contributions for the most abundant states:
  - charmonium:J/ψ(1S)
  - bottomonium:$\Upsilon(1S)$
- production mechanism models don't describe cross section and polarization simultaneously

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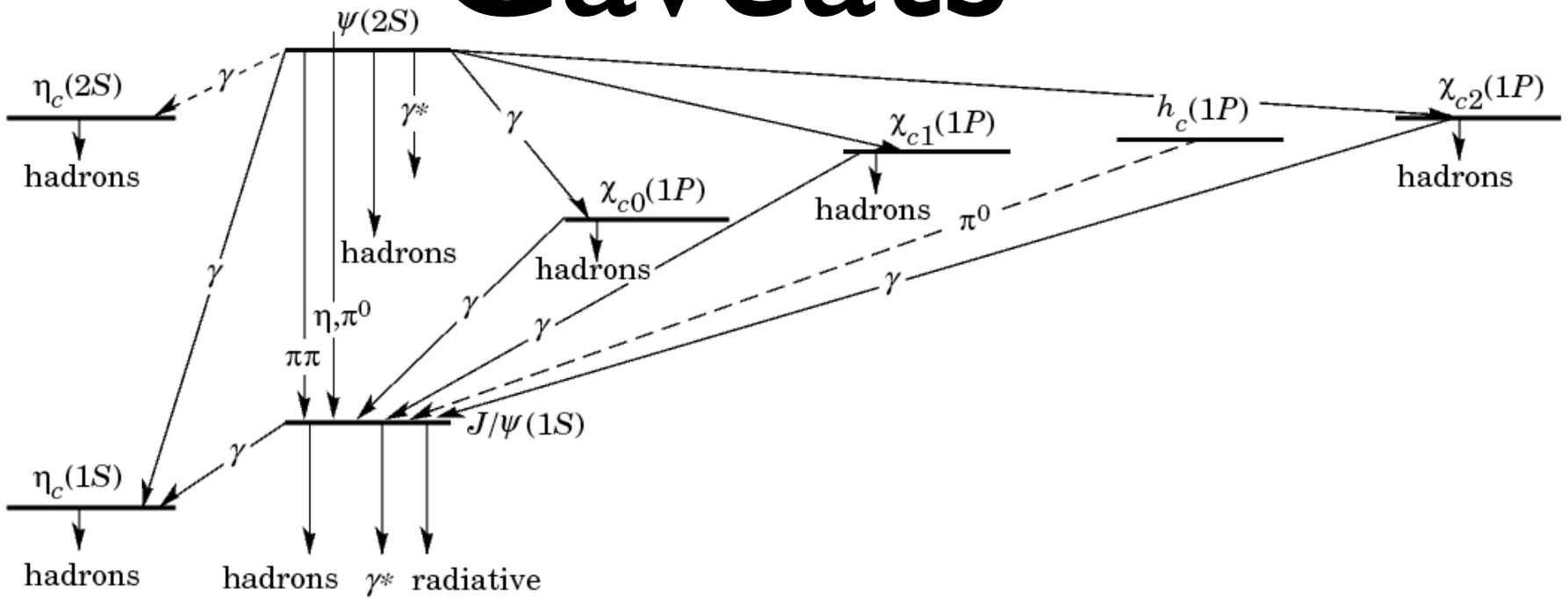

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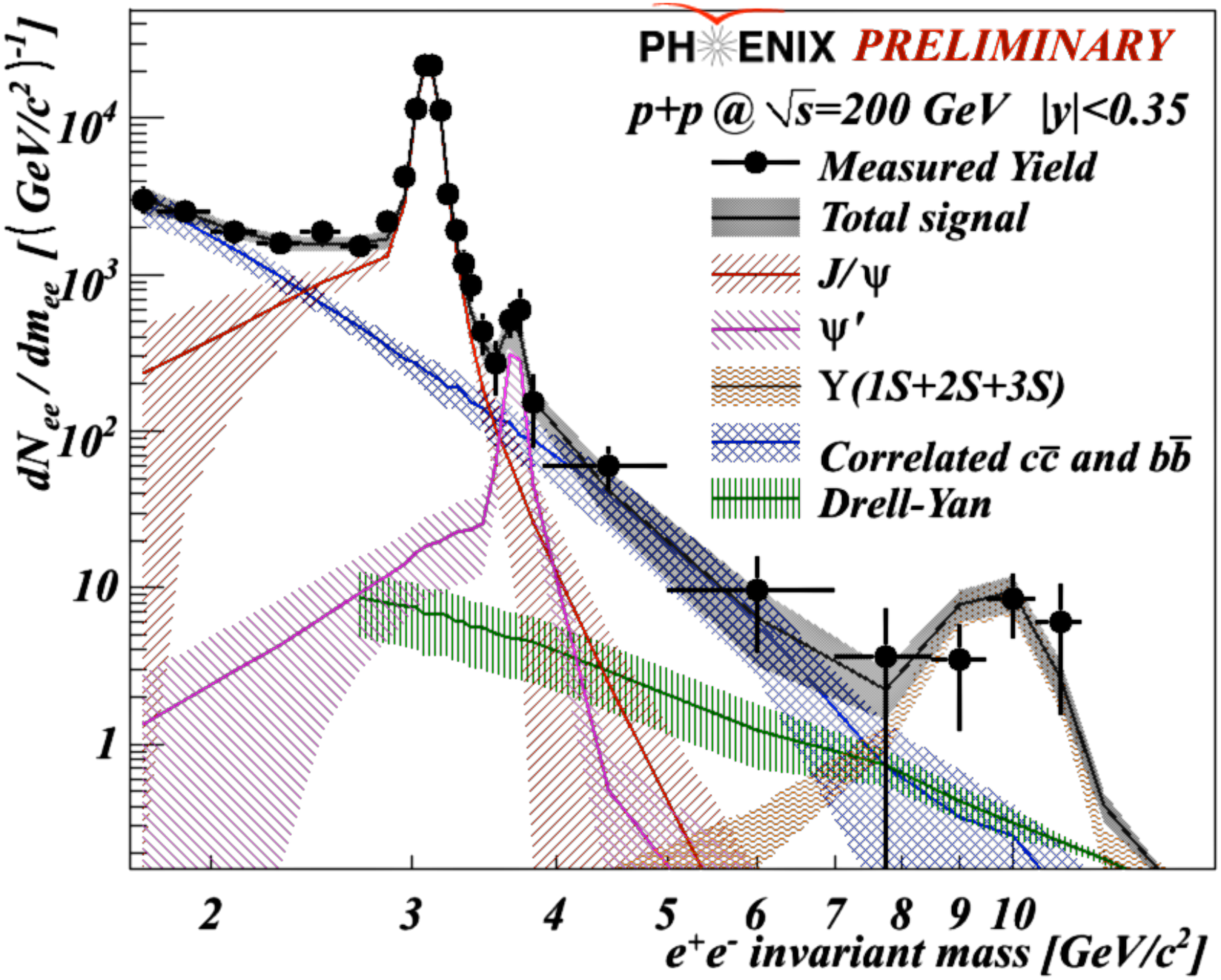
needs quarkonium measurements for different states in a broad kinematic range

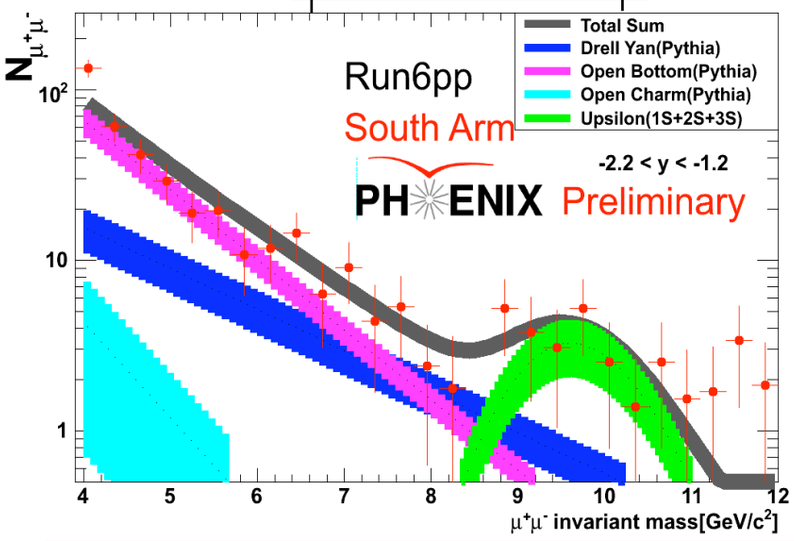
PHENIX Measures Many Quarkonium States



and has an excellent understanding of the backgrounds

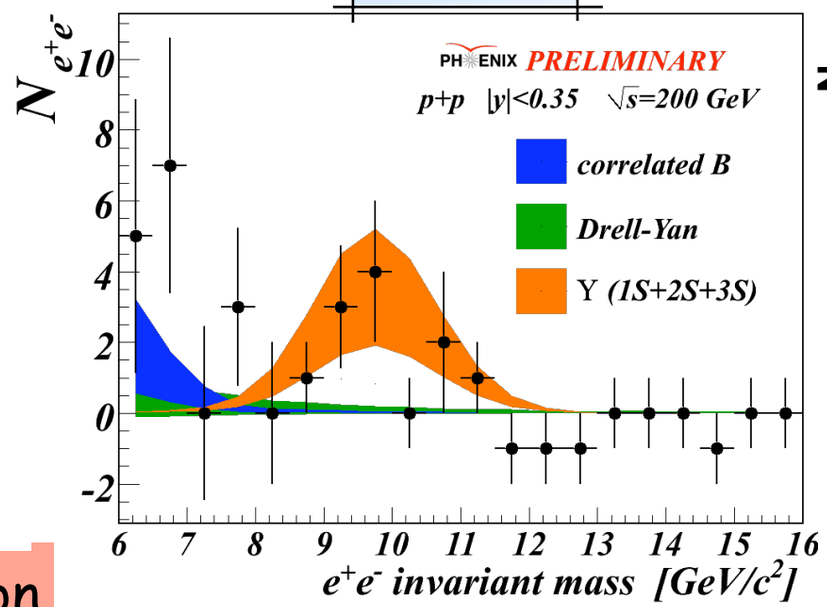
Bottomonium: Υ(1S+2S+3S)

-2.2<y<-1.2



See Kwangbok Lee presentation

|y|<0.35



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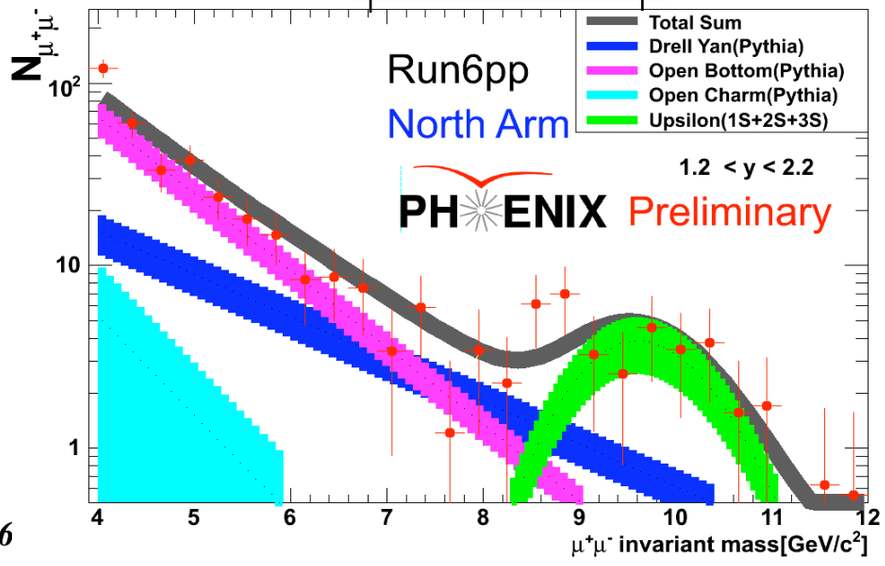

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Physical bckg. determined from PYTHIA:

- correlated $B\bar{B}$ and Drell Yan

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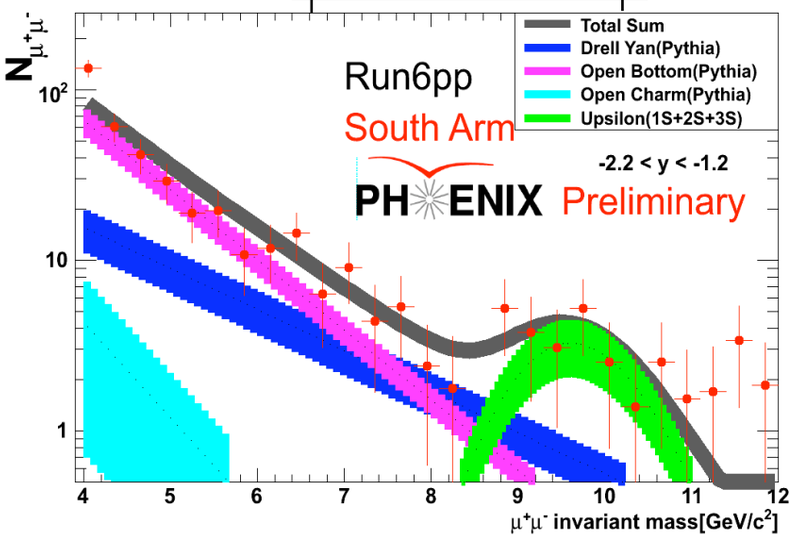

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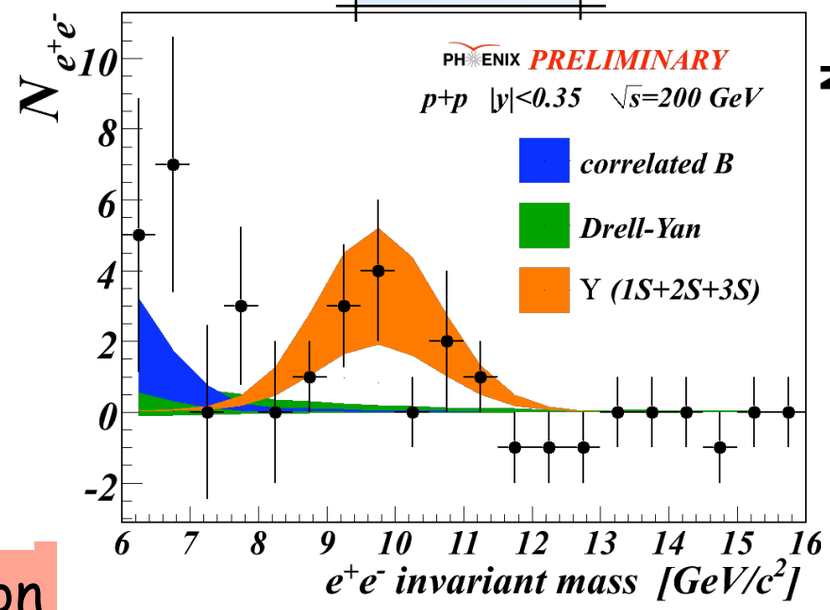

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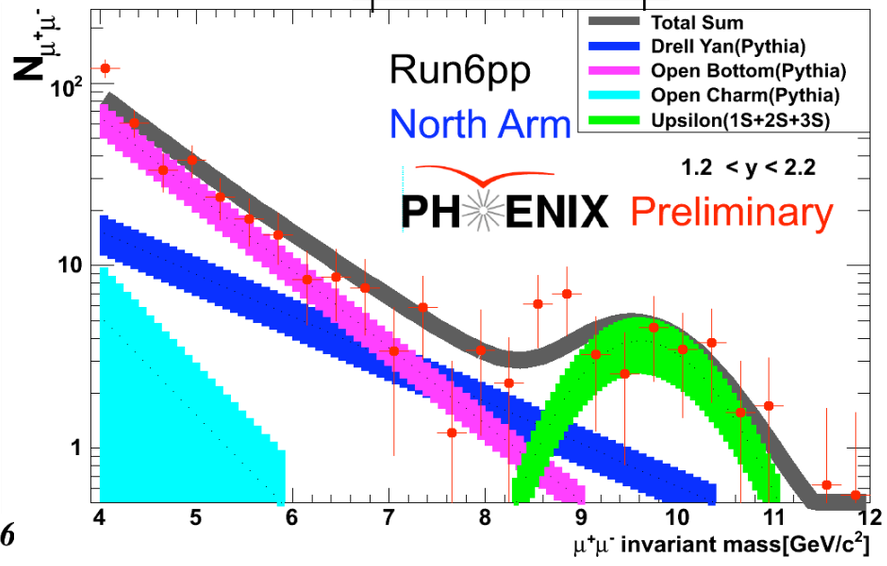

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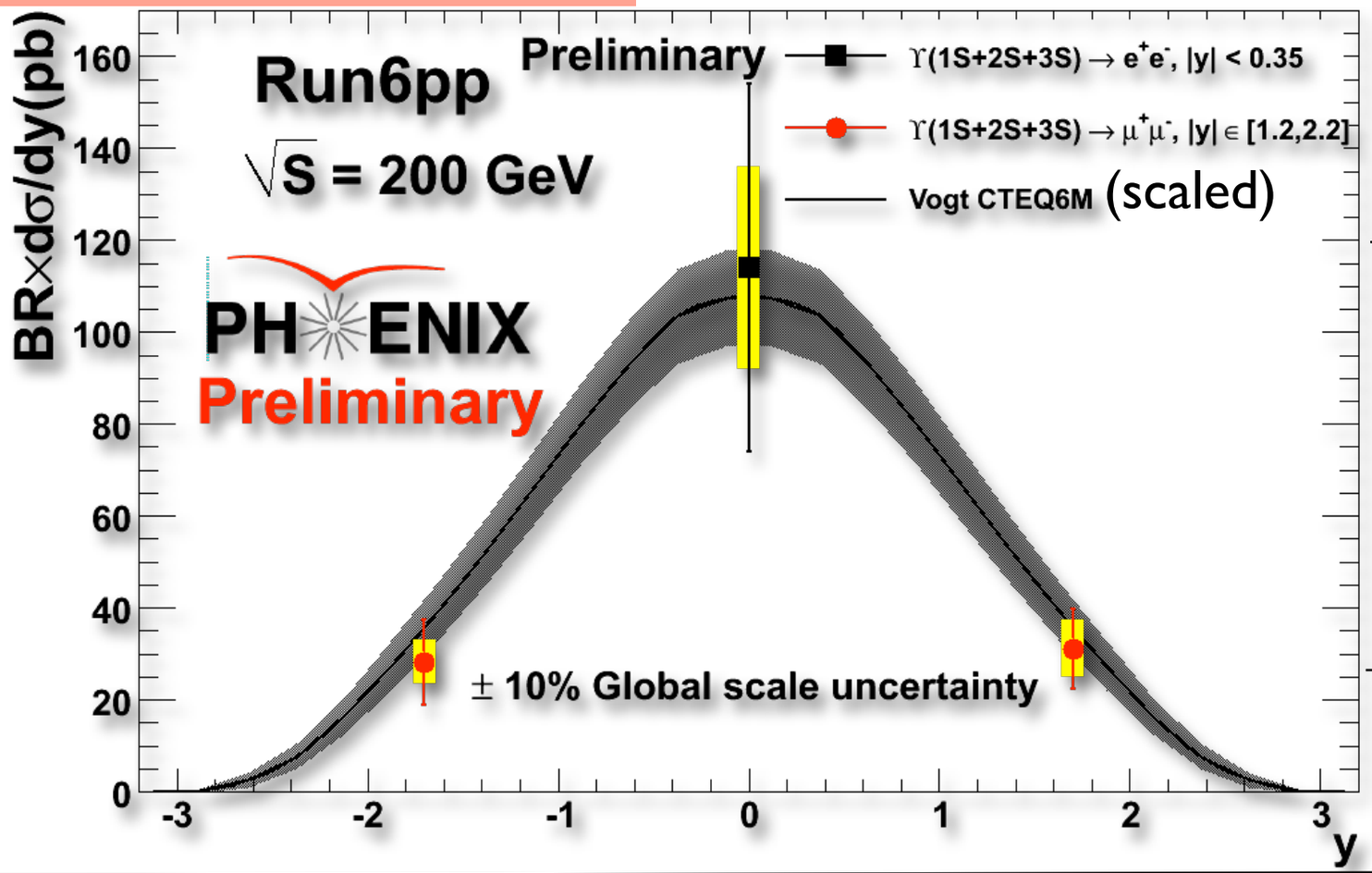

Physical bckg. determined from PYTHIA:

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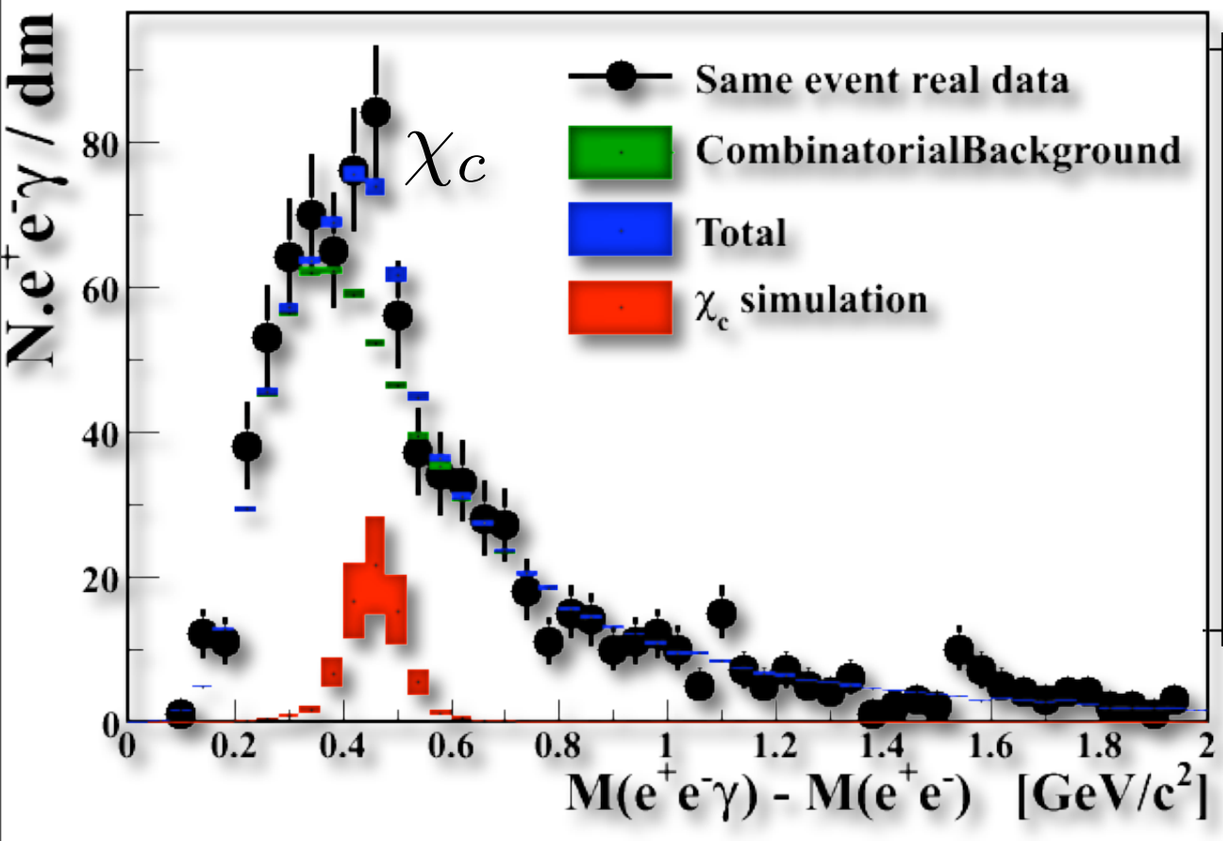
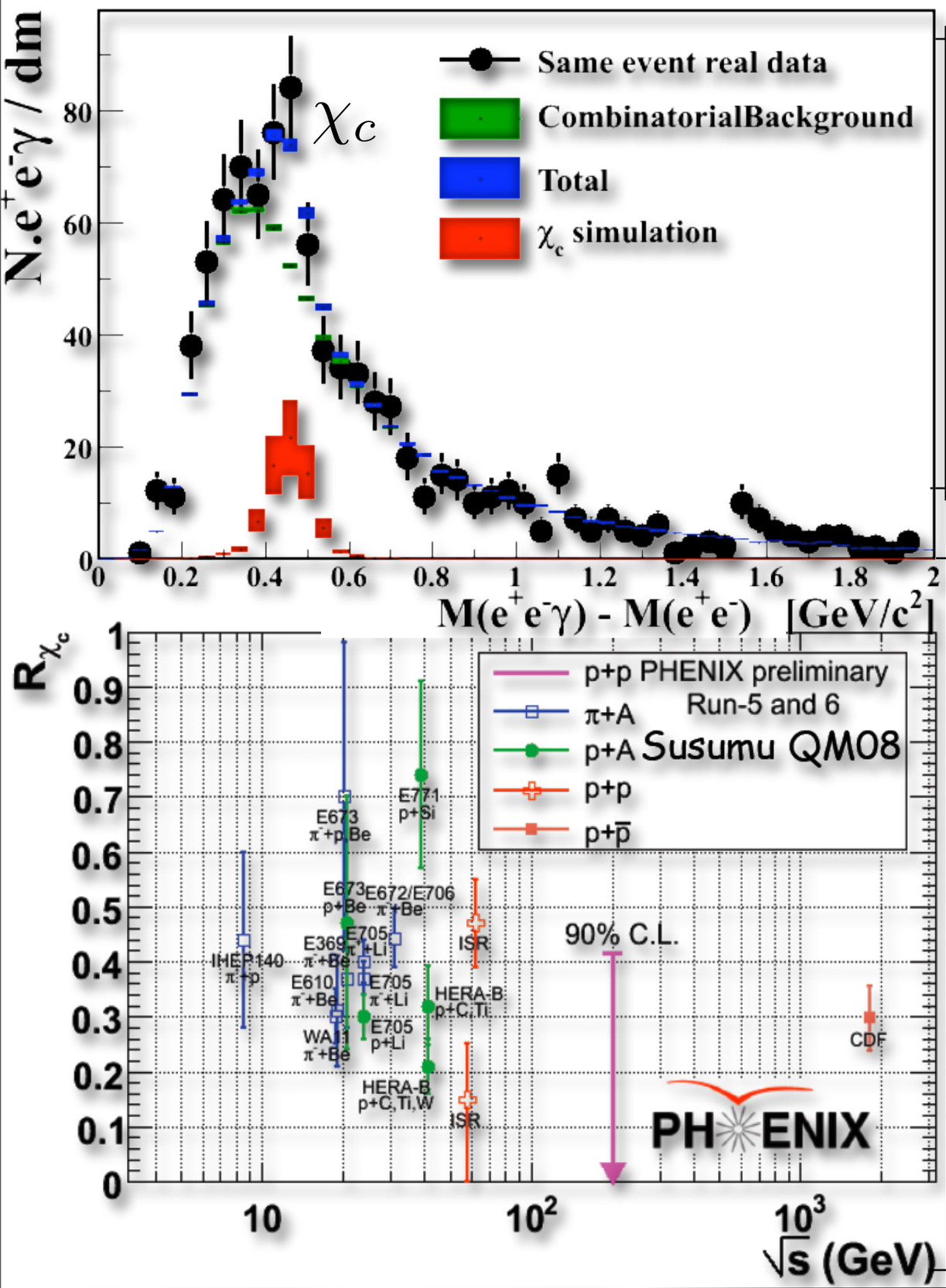
χ_C



- χ_C measured in J/ψ +γ ->e^+e^-+γ channel (|y|<0.35)
- large background from π^0
- other physical sources may also contribute: ψ' -> J/ψ+π^0 -> $e^+e^-\gamma\gamma$

χ_C



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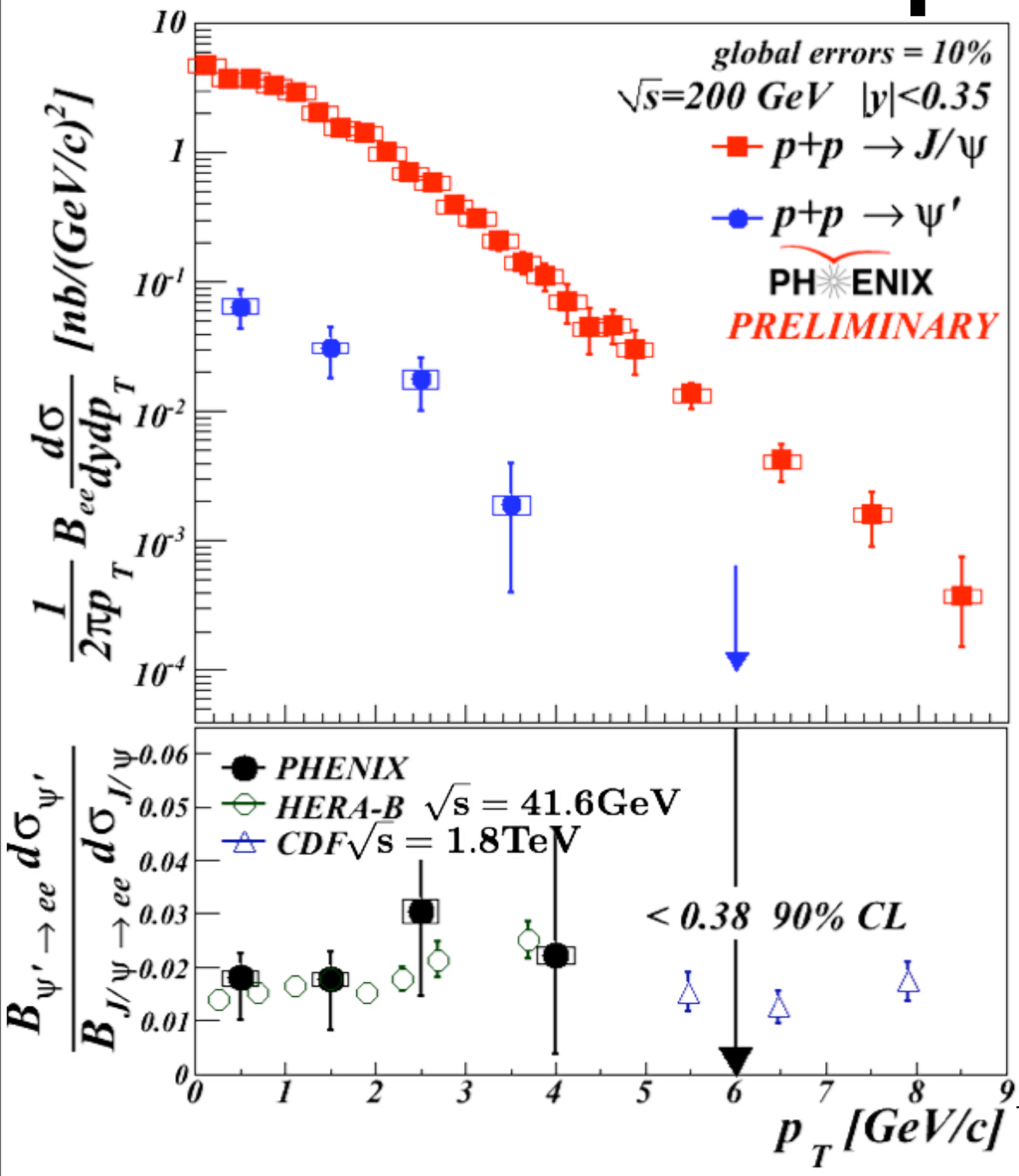
- still working in the understanding of the background
- for now 90%CL upper limit on 42% for the χ_C feed-down to J/ψ
- world average (25±5)% [Faccioli, JHEP 0810:004,2008]
- work in forward rapidity also going on (see Kwangbok preentation)

ψ'



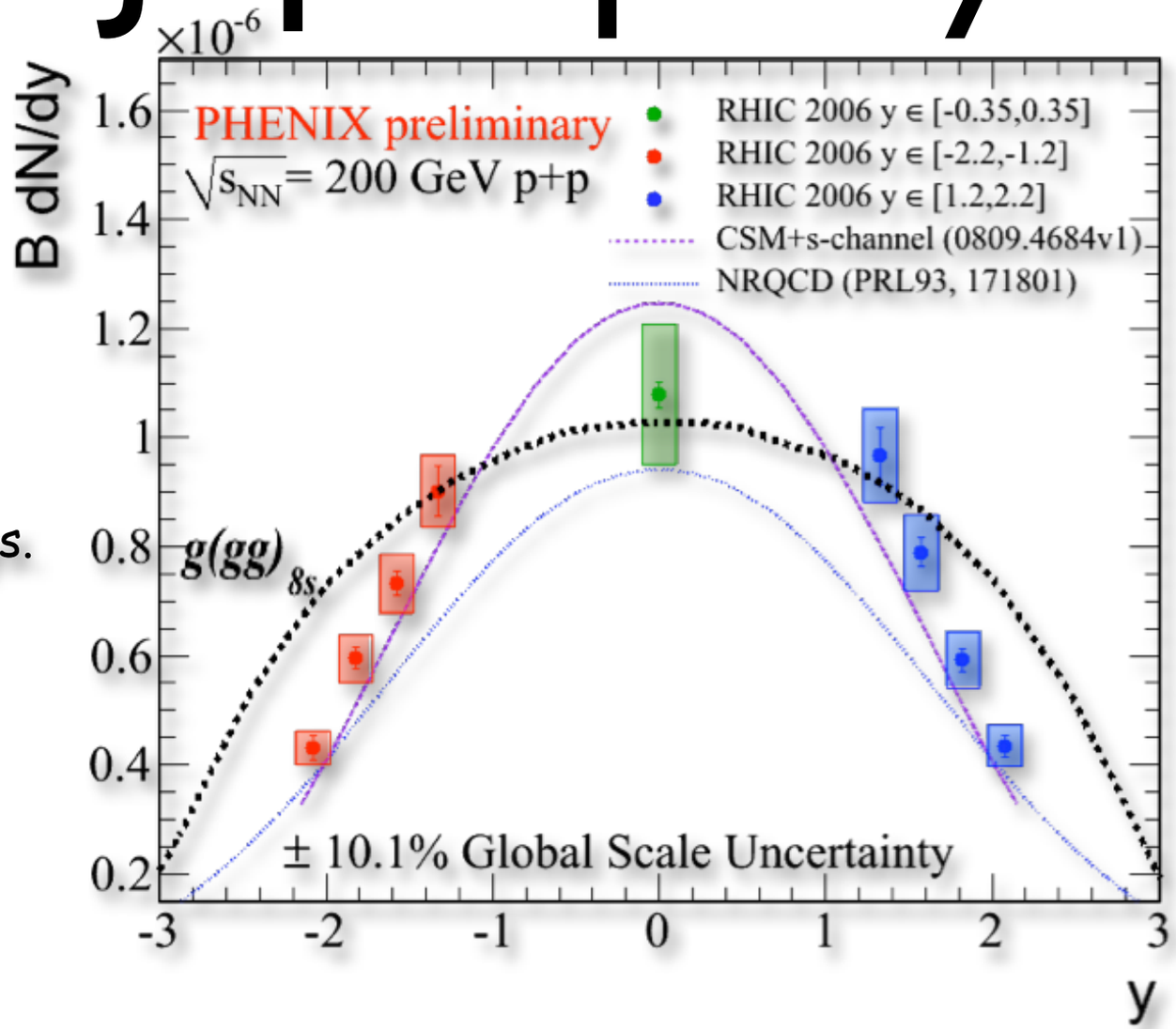
- ψ'/ J/ψ ratio in the dielectron channel about 2%
- no modification for a broad p_T and collision energies measured in other facilities
- feed-down to J/ψ

$$F_{\psi'} = B(\psi' \to J/\psi + X) \frac{B_{ee}^{\psi'} \sigma_{\psi'}}{B_{ee}^{J/\psi} \sigma_{J/\psi}} \frac{B_{ee}^{J/\psi}}{B_{ee}^{\psi'}}$$

= **(8.6 ± 2.5) %**

- world average: (8.1 ± 0.3) % [Faccioli, JHEP 0810:004,2008]
- FVTX (see Zhengyun presentation)

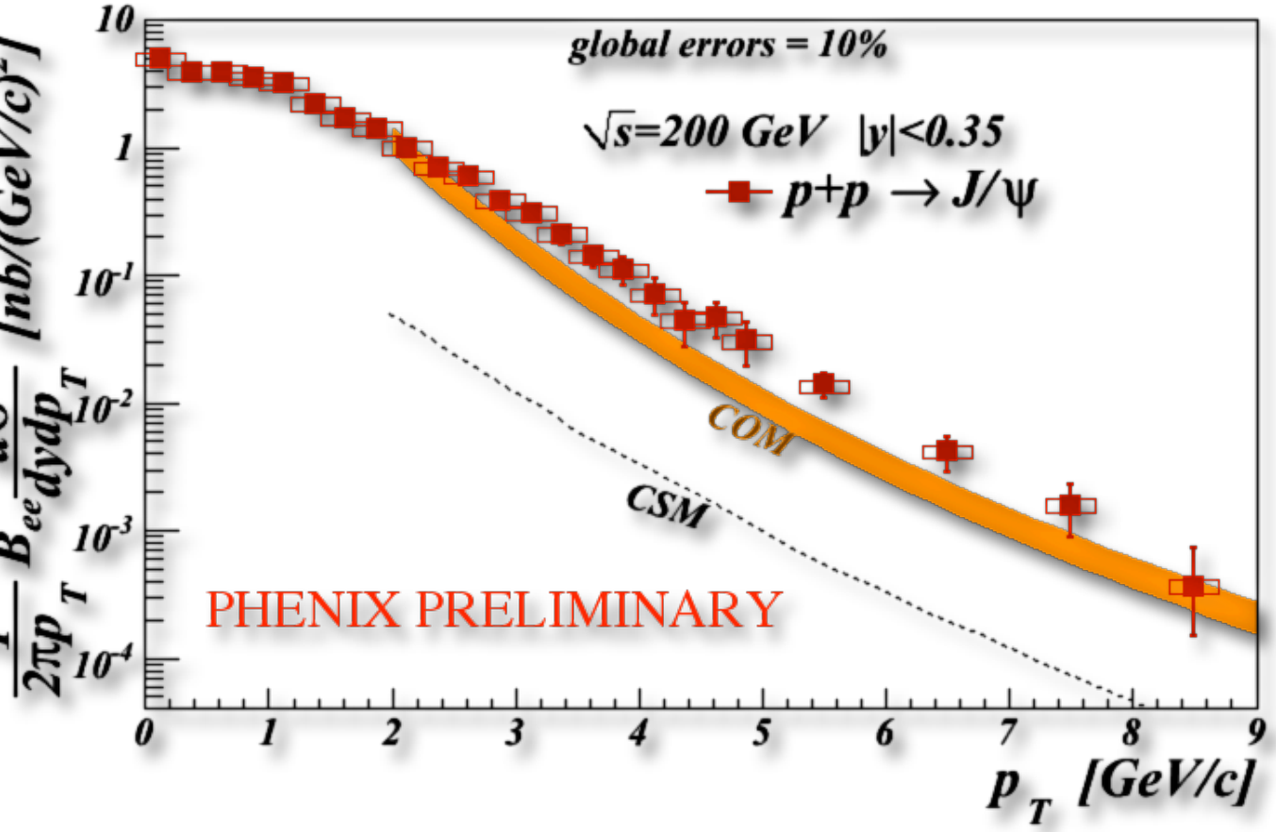
J/ψ rapidity

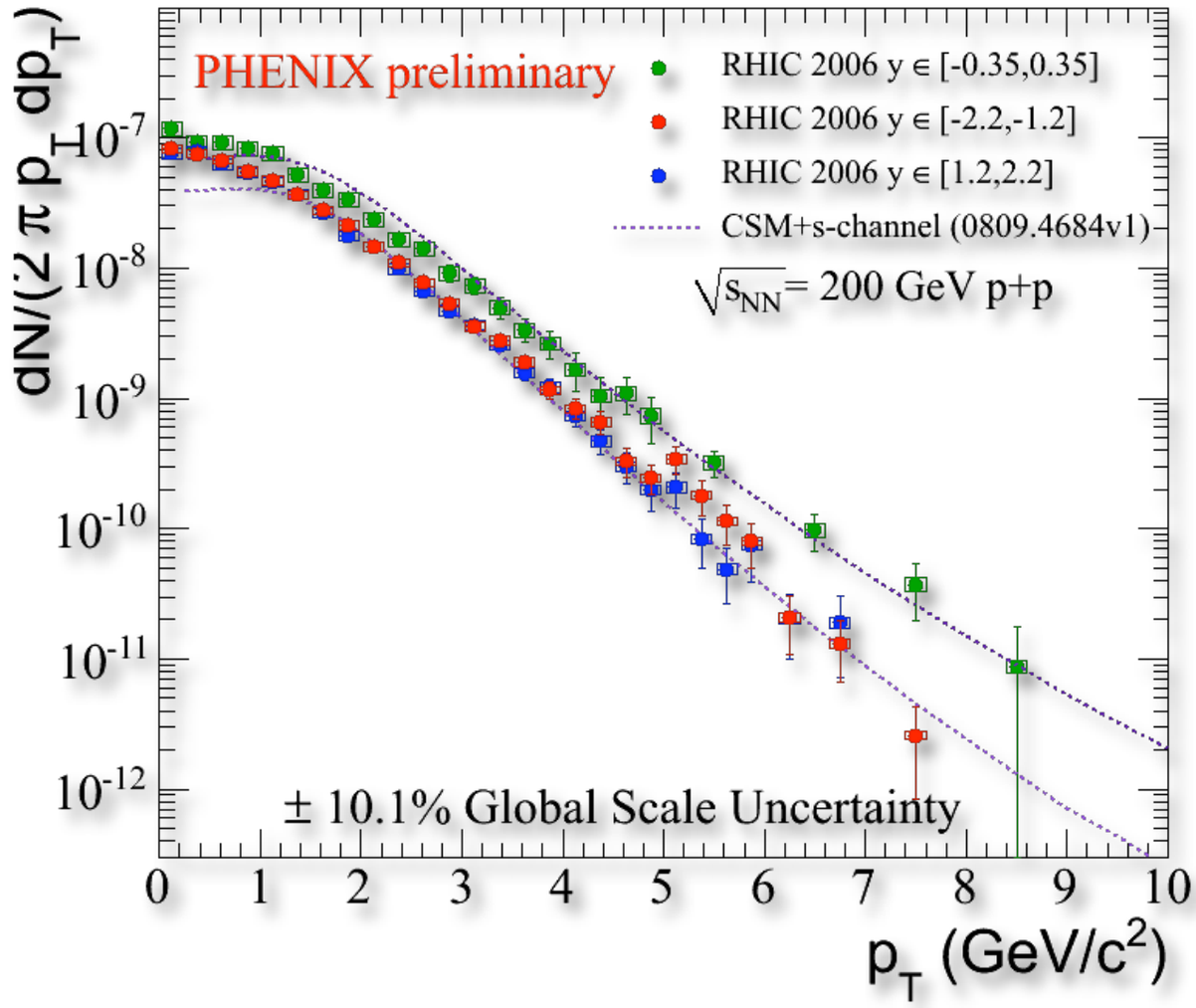


g(gg)$_8$: Khoze,Eur. Phys. J. C39,163(2005)

- J/ψ measured in e^+e^- ($|y|<0.35$) and $\mu^+\mu^-$ ($1.2<|y|<2.2$) channels
- Color singlet model (CSM) using s-channel [Haberzetti,PRL100,032006(2008)] seems to better reproduce rapidity
- Non relativistic QCD (NRQCD) model with color octet (COM) dominance is only valid for $p_T>2$ GeV/c

J/ψ pT





- original CSM (no s-channel cut) underpredict cross-section
- CSM using s-channel seems to better reproduce p_T distribution as well
- COM doesn't contain gluon fragmentation contribution

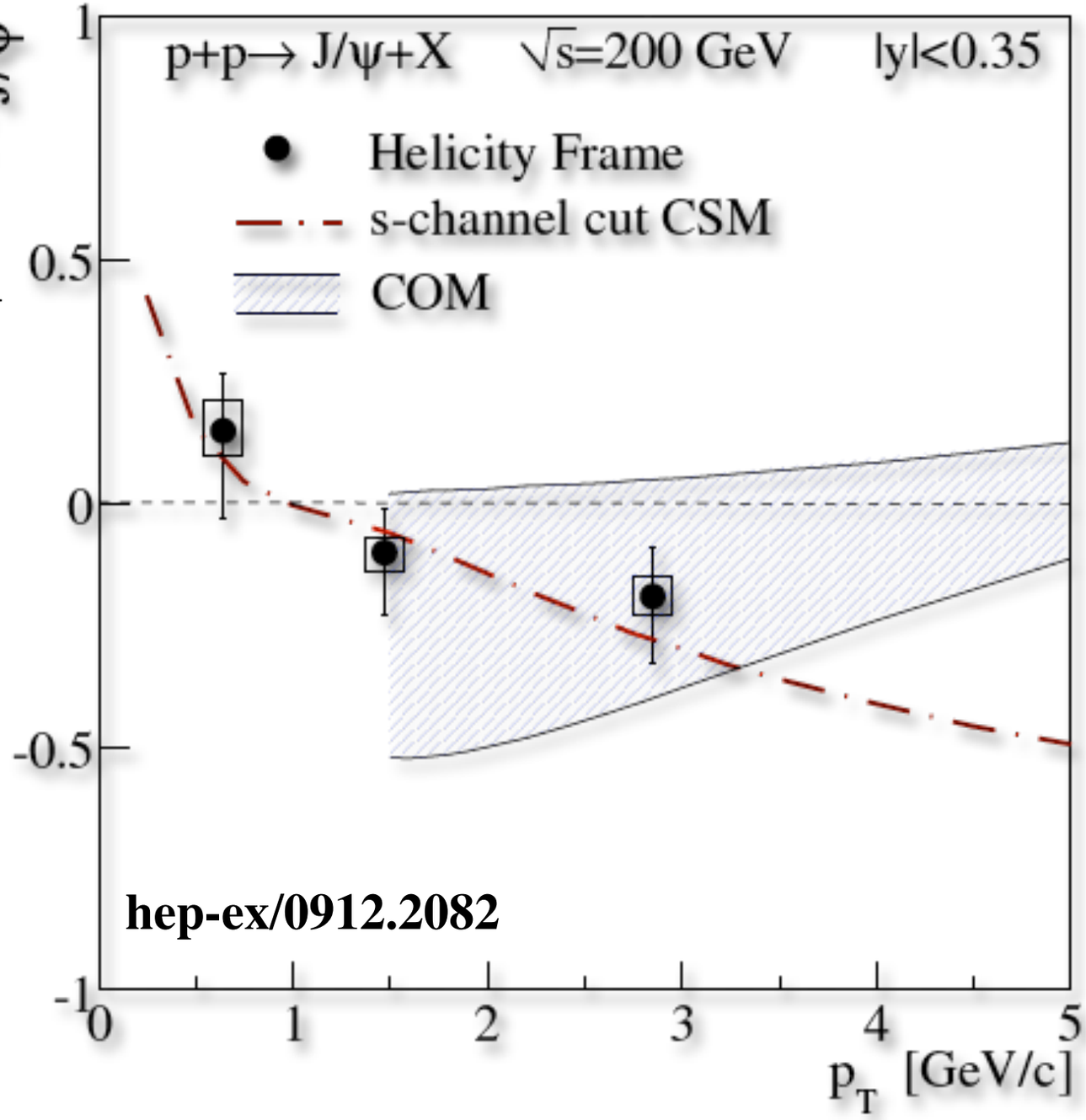
J/ψ Polarization

$$\frac{d\sigma}{dcos\theta^*} = A\left(1+\lambda cos^2\theta^*\right)$$

$$\lambda = \frac{\sigma_T - 2\sigma_L}{\sigma_T + 2\sigma_L}$$

- inclusive measurement (include J/ψ from feed-down)
- crucial test for the production mechanism
- negative polarization (λ) trend, but still consistent with zero in 2 sigma
- p_T dependence follow CSM w/ s-channel cut prediction, but still consistent with COM

See Todd Kempbel talk



s-channel CSM: AIP Conf.Proc.1038:83-92,2008

COM: B.Gong,PRD81,014020(2009)

Summary

- we started to experimentally probe how quarkonia is formed and the fraction of feed-down contributions for the ground states of charmonium
- all these data has ben used as reference in d+Au and Au+Au analysis
- available data from larger luminosity Run2009 (200 GeV and 500 GeV p+p collisions) will reduce statistical uncertainties
- future detector upgrades will make possible
  - B-> J/ψ+X after SVTX installation in 2011
  - resolve J/ψ and ψ' peaks in the forward rapidity with FVTX (2012)
  - χ_C->J/ψ+γ measuerement in the forward rapidity with MPC (under analysis) and FOCAL project